One-Stage Surgery and Early Loading of Three Implants for Maxillary Overdentures: A 1-Year Report

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ABSTRACT

Background: Maxillary implant overdentures opposing mandibular two-implant overdentures are an underused treatment option for edentulous patients. Fewer implants, simple surgery, and short healing periods may increase patients' acceptance of this treatment concept.

Purpose: To determine implant success, after overdenture loading, of three narrow-diameter roughened-surface implants placed in edentulous maxillas, using a one-stage surgical procedure, a 12-week healing period, and opposing mandibular two-implant overdentures.

Materials and Methods: Forty edentulous participants with mandibular two-implant overdentures were allocated to two groups with similar implant systems. Each group had three narrow-diameter roughened-surface implants placed into their edentulous maxillas in a one-stage surgical procedure. Standardized intraoral radiography and implant stability tests were performed sequentially at surgery, at 12 weeks (prior to loading), and at 64 weeks (after 1 year of loading with maxillary overdentures).

Results: One hundred seventeen implants were placed in 39 participants. After 1 year of loading, 15 implants had failed in 11 patients, 4 implants have been ''put to sleep'' in 3 patients, and 1 patient has died. Data on marginal bone loss and resonance frequency analysis showed no significant differences between the implant systems. The mean marginal bone loss was 1.30 mm (± 0.44 mm) from surgery to 12 weeks and 0.32 mm (± 0.48 mm) between 12 and 64 weeks with loading. The mean implant stability quotient and resonance frequency values showed a statistically significant improvement over time, at 56.05 (5,891 Hz), 57.54 (5,981 Hz), and 60.88 (6,167 Hz) at surgery, 12 weeks, and 64 weeks, respectively. The overall success rate for all implants combined was 81%, and the cumulative survival rate was 84.61%.

Conclusion: In patients with mandibular two-implant overdentures, three narrow-diameter roughened-surface implants can be placed in the edentulous maxilla, using a one-stage surgical procedure, and can be loaded within 12 weeks with overdentures for 1 year.

KEY WORDS: early loading, maxillary overdentures, one-stage procedure, resonance frequency analysis

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There is a lack of randomized controlled clinical trials for patients treated with maxillary overdentures opposing mandibular two-implant overdentures. The literature reports on patients who have either natural teeth or fixed implant bridges in the mandibular arch opposing the maxillary overdenture.[1–5] The use of just two implants to support maxillary overdentures is not supported by the literature.[2,6] Instead it has been

recommended that a minimum of three implants with a length of 7 mm or more and a ''standard'' rather than ''narrow'' diameter should be used.[7] However, more often than not, the standard surgical request is for four to eight well-spaced implants over the arch in order to embrace the biomechanical concept of fixed prostheses and to maximize the stability of the overdenture. This is consistent in planned and unplanned studies as well as retrospective case reports of maxillary implant overdenture treatment.[2,3,8–11] Future cost-effective therapeutic directions for the edentulous maxilla require a change in the way we treat the edentulous predicament.[4,12] The number of surgical operations and healing time should be minimized, provided this does not compromise implant success. In addition, patients report that wearing their existing maxillary denture with a tissue conditioner during a prolonged implant healing period is difficult and uncomfortable, and clinicians find that frequent replacement of the temporary soft liner is time-consuming and frustrating.[13]

Resorption of the edentulous maxilla[14–16] results in a loss of ridge height and width, which often compromises the placement of implants of ''standard'' diameter.[17] If implants are not placed shortly after the patient becomes edentulous, progressive horizontal and vertical jaw atrophy may compromise maxillary denture retention and stability to a degree that is unacceptable to the patient.[18] Such atrophic ridges frequently require extensive bone grafting and/or membrane-guided bone regeneration before implants can be placed.[19–26] These procedures commit older adults to a series of costly and uncomfortable surgical appointments that they may not be emotionally or medically prepared to undergo. Failures can be catastrophic, and patients may be left worse off as a result of the treatment. Often, patients decline the option of onlay bone grafting. An alternative grafting procedure using the maxillary sinus has scanty and contradictory scientific support.[27] Another alternative, where there is insufficient bone, would be the use of narrow-diameter implants. Currently, so-called standard-diameter implants are considered essential to support maxillary overdentures although recommendations suggest that a small number of shorter or narrow-diameter implants may be included among a sufficient number of implants of standard length (> 10 mm) and regular diameter (3.75 to 4.10 mm).[2] Reduced maxillary bone volume following atrophy is frequently compounded by the presence of poor-quality bone; these two factors have been shown to result in increased implant failure for these patients, compared to patients who have favorable jawbone characteristics at the time of implant surgery.[28] A 5-year prospective study on Brånemark® implants (Nobel Biocare AB, Göteborg, Sweden) supporting overdentures yielded a 72.4% success rate; evidence with respect to the optimum number of implants to use when treating the edentulous maxilla was inconclusive.[29] Further research has been recommended to resolve this matter.[7] For patients who have minimally resorbed maxillary ridges that are narrow bucco-palatally and that oppose a mandibular two-implant overdenture, we suggest that an alternative approach may be earlier intervention with narrow-diameter implants. Cognizance does need to be taken of their diminished mechanical strength[7]; however, we suggest that when the overdenture has full palatal coverage, it is being supported by both the implants and the primary stress-bearing area of the palate. In addition, less invasive surgical techniques can be used.[30–33] It may be time to reevaluate surgical treatment planning for maxillary overdentures when opposing mandibular two-implant overdentures, in order to reduce the clinical and financial barriers to treatment for a wider segment of the population.[34]

The goal of this study was to determine the degree of implant success after 1 year of overdenture loading of three narrow-diameter roughened-surface implants placed in edentulous maxillas (and loaded after a 12-week healing period) and opposing mandibular two-implant overdentures.

MATERIALS AND METHODS

Patient Sample

This study recruited 40 edentulous participants who had a conventional maxillary denture opposed by a mandibular two-implant overdenture and who were part of the Clinical Overdenture Research Project (CORP) at the School of Dentistry, University of Otago, Dunedin, New Zealand. To be included, a patient had to be 55 to 80 years of age, have an edentulous maxilla, and have successfully worn his or her mandibular two-implant overdenture for at least 3 years. Excluded from the study were those with Lekholm and Zarb classification[16] type E maxillas (determined radiologically), a history of smoking, a systemic disease likely to com-

Figure 1 Implant systems with roughened turned surfaces. *A,* Brånemark System, narrow diameter, 3.3 mm. *B,* Southern Implant system, narrow diameter, 3.25 mm.

promise implant surgery, previously bone-grafted jaws, or a history of bruxism. Ethical approval was obtained from the Otago Ethics Committee.

Using a table of random numbers, the participants were randomly allocated (with maximum concealment)[35] to one of two roughened-titanium-surface implant systems (Brånemark System®, Nobel Biocare AB, Göteborg, Sweden, and Southern Implant System®, Southern Implants, Irene, South Africa) (Figure 1). The clinical protocol was composed of a one-stage surgical procedure and 12-week postoperative healing before loading. The Brånemark implants had a TiUnite™ (Nobel Biocare AB) oxidized surface,[36] and the Southern implants had an acid-etched and blasted surface.[37] Preoperative diagnostic panoramic radiography and spiral tomography (Scanora®, Soredex, Orion Corporation, Helsinki, Finland) were used

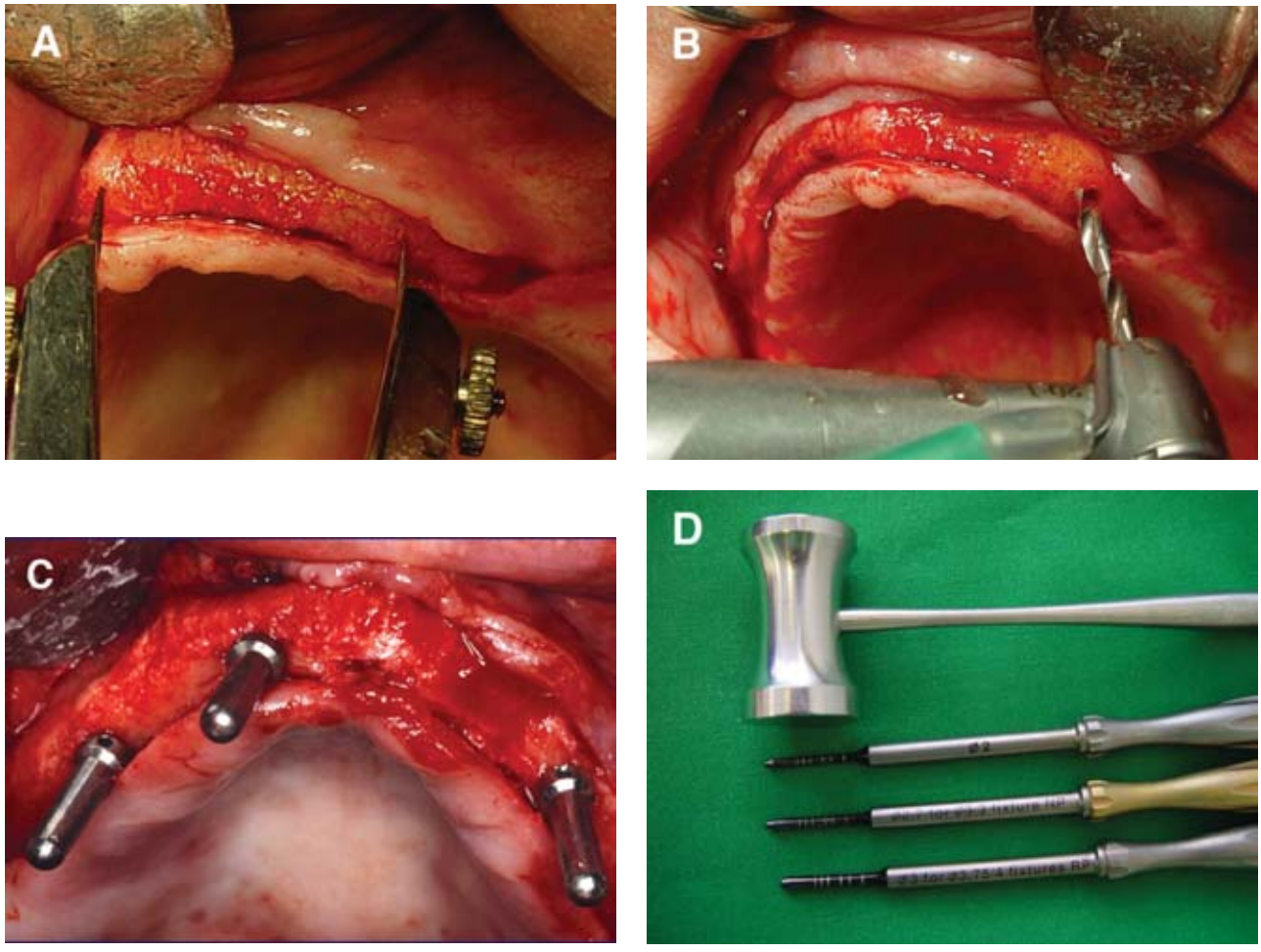

Figure 2 Osteotome-only procedure. *A,* Flap elevation and posterior site selection. *B,* 2 mm twist drill. *C,* Three sites with direction indicators. *D,* Brånemark osteotome set with mallet.

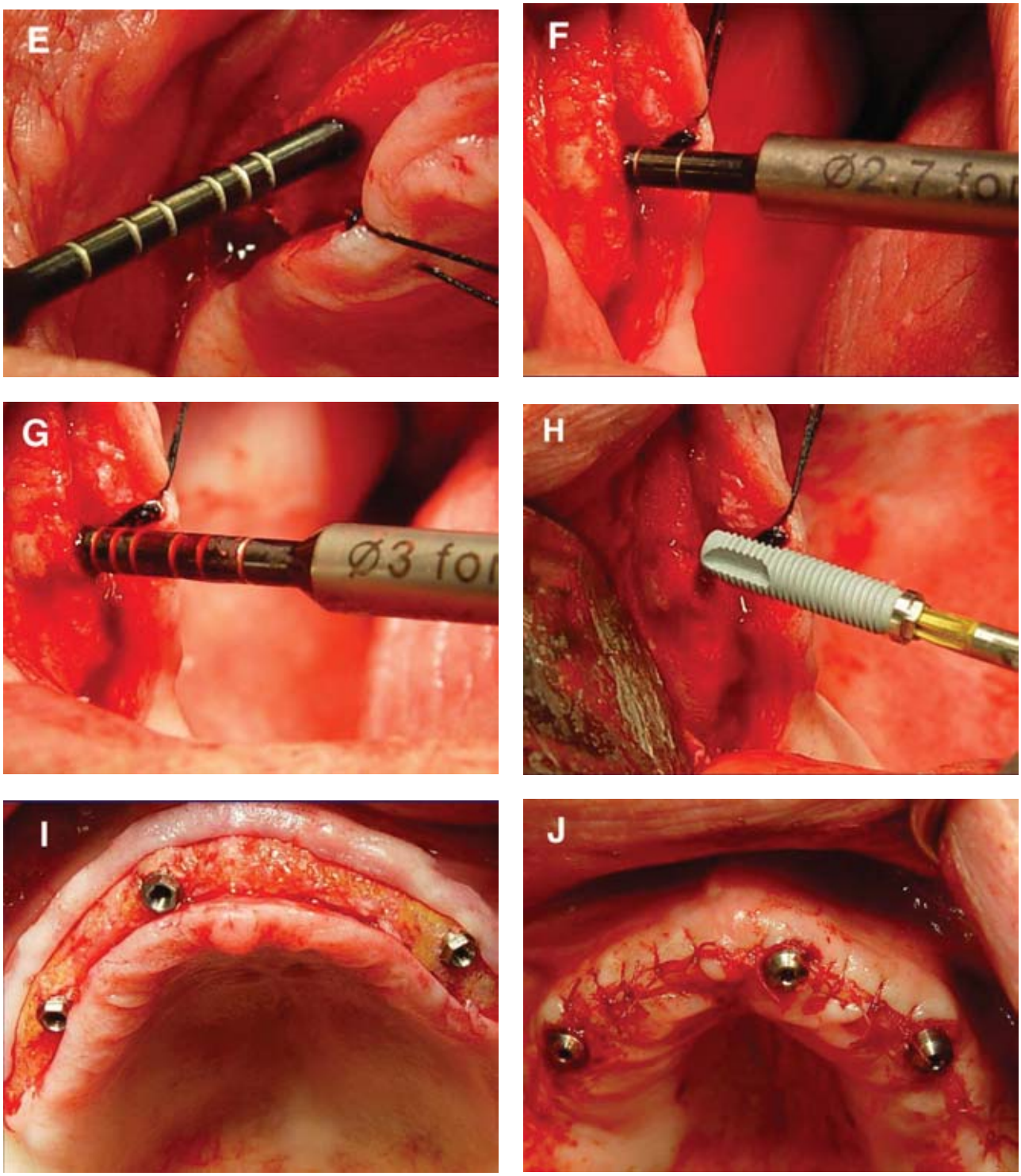

Figure 2 (*continued*). Osteotome-only procedure. *E,* 2 mm osteotome. *F,* 2.7 mm osteotome. *G,* 3 mm osteotome. *H,* Narrow-diameter 3.3 mm roughened-surface titanium implants. *I,* Completed implant placement. *J,* Healing abutments placed, after one-stage procedure and flap closure.

to facilitate patient selection and implant placement.[38] Each participant's existing maxillary denture was used as a radiographic stent, with tinfoil markers placed in the midline area and bilaterally 20 mm distally (determined by dividers) to correspond with each premolar region. Maxillary overdentures were to be used to load the implants from 12 to 64 weeks.

Surgical Procedures

With the patient under local anesthesia and standard antibiotic cover, the edentulous maxilla was exposed via a continuous midcrestal incision connecting both premolar regions, with vertical relieving incisions distally. Mucoperiosteal flaps were elevated minimally to expose only the alveolar ridges, which were carefully leveled to a width of 3 mm. The anterior implant sites (area 11/21) in zone I[39–41] were selected on either side of the incisive canal to avoid expansion of the maxillary suture.[7] Two posterior sites (areas 14 and 24) were selected distal to the canine eminence in the anterior portion of zone II of each maxilla. The entry points were 20 mm either side from the midline, corresponding to the radiographic markers, with a path of preparation along the anterior border of the maxillary sinus

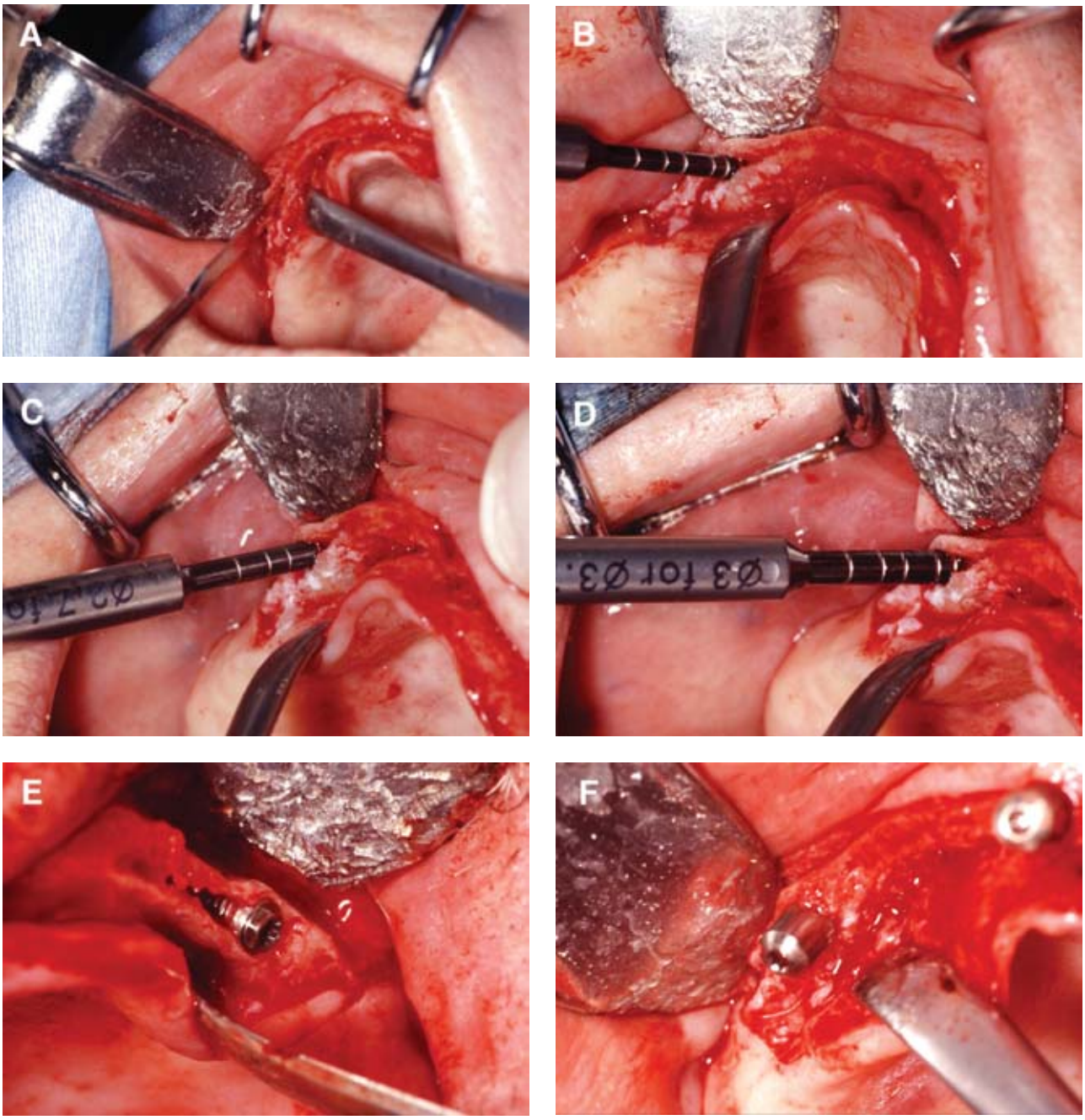

Figure 3 Osteotome and ridge-split procedure. *A,* Narrow edentulous maxillary ridge splitting. *B,* 2 mm osteotome for site preparation without use of a twist drill. *C,* 2.7 mm osteotome. *D,* 3 mm osteotome. *E,* Implant placement, showing exposed threads, prior to autogenous bone pack. *F,* Healing abutments placed with one-stage procedure and flap closure.

for a distally angled implant site[42–44] (Figure 2A). Participants had either a ridge-expansion-with-osteotome-only (OO) procedure[30] or a combined ridge-split-and-osteotome procedure (ORS),[32] depending on ridge bucco-palatal width and the degree of ridge resorption detected radiographically (Figure 3A–D; also see Figure 2B–G). Hence, the choice of surgical procedure was dependent on ridge anatomy and was not randomized. Bone quality and quantity were evaluated with the Lekholm and Zarb classification.[16]

Three roughened-surface screw-shaped narrow-diameter titanium implants (Brånemark 3.3 mm; Southern 3.25 mm) were placed (one anterior and two posteriorly) for all participants (see Figure 2H and I and Figure 3E). Exposed threads in the intra-osseous groove of the ridge-split cases were filled with corticocancellous autogenous bone. Bicortical anchorage to enhance primary stability was obtained,[7,45] and bucco-palatal angulation of the implants up to 30° was allowed. Standardized intraoral radiography and implant stability tests (Osstell™, Integration Diagnostics AB, Göteborg, Sweden) were taken at implant level for each implant. Healing abutments (all 4 mm) were placed as part of the one-stage placement protocol, following previously demonstrated high success rates in the mandible[46,47] (see Figure 2J and Figure 3F). Mucoperiosteal flaps were trimmed to remove excess tissue and were sutured around healing abutments (4–0 Vicryl®, Ethicon, Johnson & Johnson, Brussels, Belgium). Immediately after the operation, conventional maxillary dentures were relieved and relined with tissue conditioner (Viscogel®, Dentsply DeTrey GmbH, Konstanz, Germany) opposing the mandibular two-implant overdentures. A twice-daily

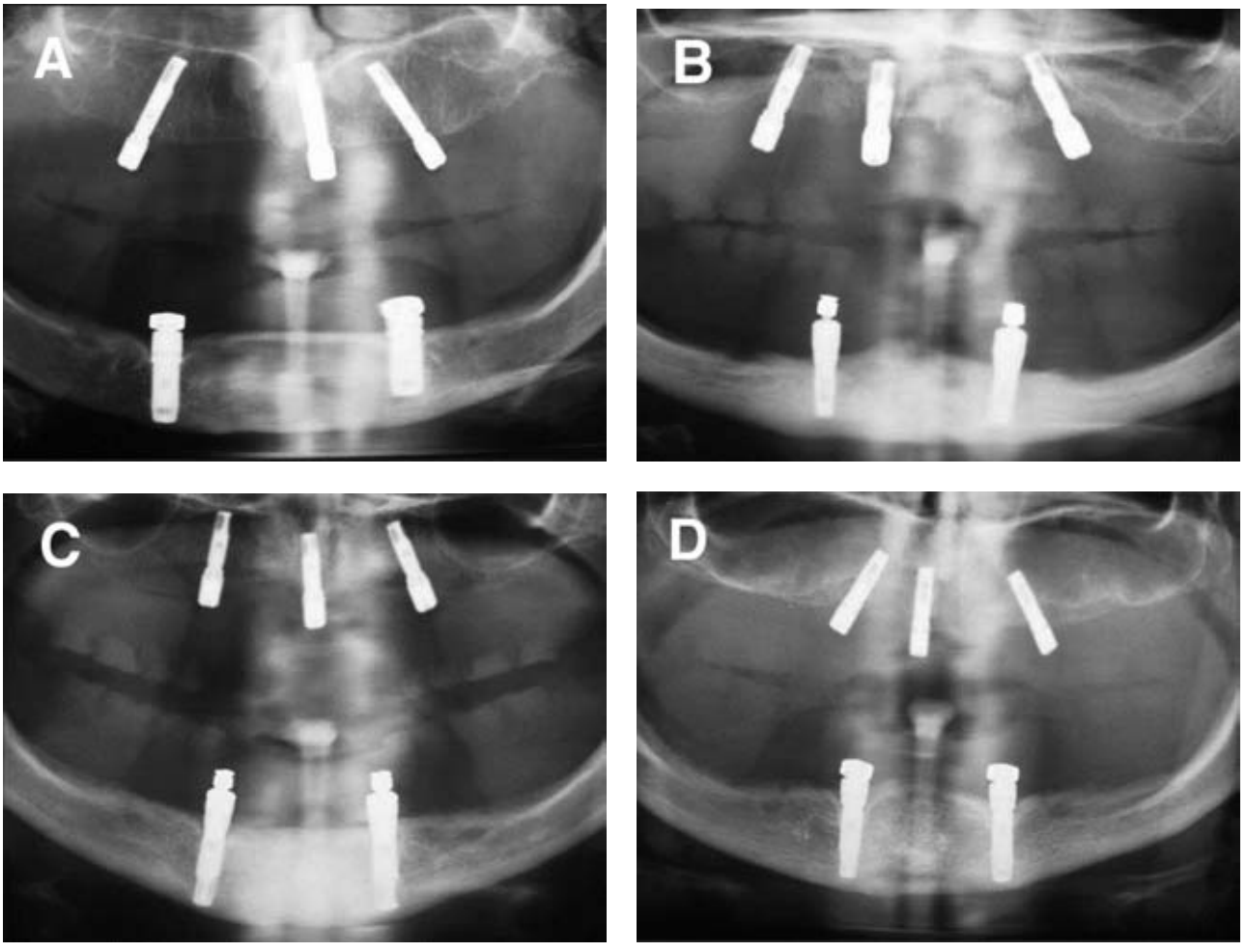

Figure 4 Panoramic radiographs showing postsurgical result in an edentulous maxilla with existing mandibular two-implant overdentures.

TABLE 1 Distribution of Implants by Length and Implant System

		Implant System					
		Brånemark			Southern		
Implant Length (mm)	Total Study Group	14 Area	11/21 Area	24 Area	14 Area	11/21 Area	24 Area
10.0	34	3	4	3	8	8	8
11.5	17	5	4	5	1	1	1
13.0	15	1	3	1	2	4	4
15.0	51	10	8	10	9	7	7
Totals of implants placed	117	19	19	19	20	20	20

bilateral periimplant application of 0.2% chlorhexidine gel (Perioguard™, Colgate Oral Care, Sydney, Australia), 0.2% chlorhexidine mouthrinses, and a soft diet were recommended.

Follow-Up

At 12 weeks the healing abutments were removed (Figure 4), permanent abutments were placed, and existing complete maxillary dentures were relined with matrix inclusion to facilitate functional loading. Follow-up standardized intraoral radiography and implant stability tests were performed at 12 and 64 weeks, to evaluate implant success.[48] Participants were advised to brush with end-tufted and electric toothbrushes.[49]

Data Analysis

Marginal bone level changes and implant stability measurements (implant stability quotient [ISQ] and resonance frequency [RF] values) were computed from readings at surgery and at 12 and 64 weeks. These were compared, using the Wilcoxon test for related samples, while differences in proportions were tested for statistical significance by using the chi-square test (or the McNemar test when change over time was examined). All data were analyzed with SPSS® 10 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $p < .05$. Success rates of the implants grouped together and by system were examined.

RESULTS

Clinical Findings

A total of 117 implants were placed in 39 participants (21 female, 19 male; mean age, 64 years; age range, 55 to 76 years) (Table 1). One participant in the Brånemark group was excluded because only one anterior

TABLE 2 Bone Quantity versus Number of Implants for Each Surgical Technique

	All Participants, by Number (n = 117)		Osteotome Only (n = 69)		Osteotome and Ridge Split (n = 48)	
Bone Quantity*	No.	%	No.	%	No.	%
A	9	7.7	9	13.1	—	—
B	45	38.5	39	56.5	6	12.5
C	42	35.9	15	21.7	27	56.3
D	21	17.9	6	8.7	15	31.2

n = total number of implants.
*According to Lekholm and Zarb classification.

TABLE 3 Bone Quality versus Number of Implants per Surgical Technique

	Anterior Sites 11/21		Posterior Sites 14 and 24	
Bone Quality*	Osteotome Only (*n* = 69)	Osteotome and Ridge Split (*n* = 48)	Osteotome Only (*n* = 69)	Osteotome and Ridge Split (*n* = 48)
1	—	—	3	—
2	24	27	3	18
3	39	18	33	15
4	6	3	30	15

n = total number of implants.
*According to Lekholm and Zarb classification.

implant could be placed. Twenty-three participants (59%) had the OO procedure while 16 (41%) had the ORS procedure. The ORS procedure was used more in participants with Lekholm and Zarb bone quantity C or D (Table 2). There was a significant difference detected between bone quantity and the surgical technique used (p = .005). The association between bone quality and surgical procedure was not significant;

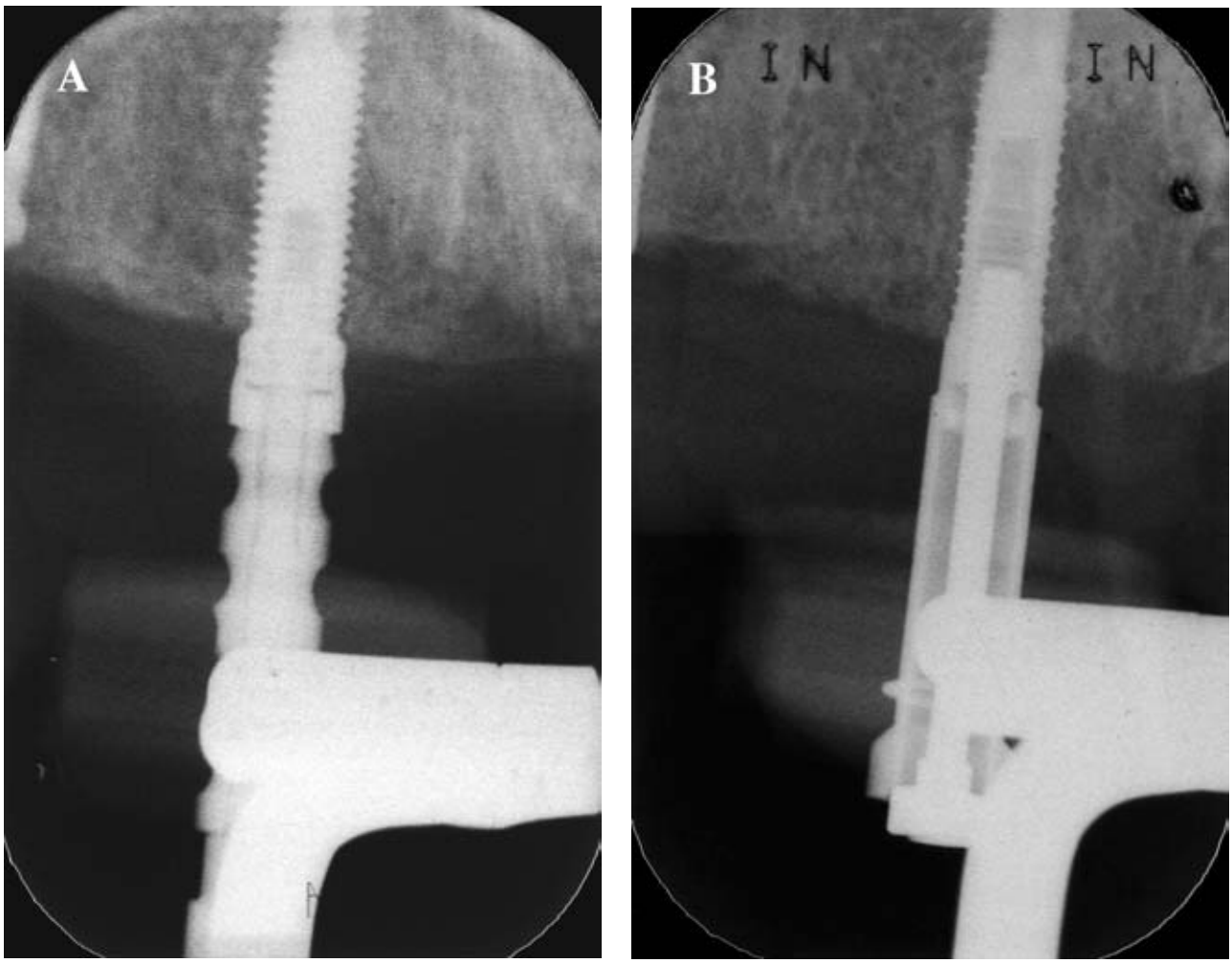

Figure 5 Standardized radiographs showing implants. *A,* Brånemark implant. *B,* Southern implant.

TABLE 4 Implant Stability Quotients and Resonance Frequency Analysis

	No. of Participants	Total Study Group	Brånemark Implant Total Group	Southern Implant Total Group
Mean ISQ				
At surgery	39	56.05 (± 5.13)	56.98 (± 5.40)	55.17 (± 4.82)
At 12 weeks*	39	57.54 (± 4.71)	58.21 (± 4.67)	56.91 (± 4.79)
At 64 weeks†	35	60.88 (± 4.15)	60.84 (± 4.47)	60.92 (± 3.92)
Mean RF (Hz)				
At surgery	39	5,891 (± 304)	5,958 (± 319)	5,828 (± 283)
At 12 weeks*	39	5,981 (± 276)	6,047 (± 270)	5,918 (± 275)
At 64 weeks†	35	6,167 (± 235)	6,181 (± 251)	6,152 (± 224)

ISQ = implant stability quotient; RF = resonance frequency.
*Significant difference from surgery to 12 weeks for both systems combined (ISQ and RF; $p = .005$ and $p = .008$).
†Significant difference from 12 weeks to 64 weeks (for both systems combined) (ISQ and RF; $p = .001$ and $p = .002$).

however, the ORS procedure was 1.5 times more likely to be used with good-quality bone, and the OO procedure was twice as likely to be used when poor-quality bone was present (Table 3). Twenty-seven (23%) of the 117 healing abutments placed loosened during the 12-week healing period, and they were carefully resecured without discomfort to the participants.

Success Rates

Prior to overdenture loading at 12 weeks, 11 implants failed, as indicated by extrusion at the time abutments were removed for radiography and stability tests. There were 4 failures of Brånemark implants in 3 patients and 7 failures of Southern implants in 7 patients. Of those 11 implant failures, 8 (73%) were in participants in whom the ORS procedure had been used (in type C/D bone quantity) whereas the other 3 failures (27%) were in participants in whom an OO procedure had been used. Of the latter group, two had type B bone quantity and one had type D bone quantity. The survival rate with the OO procedure was 95.7%, or 66 of 69; the rate was higher with the ORS procedure, at 83.3%, or 40 of

TABLE 5 Mean Changes in Implant Stability Quotient and Resonance Frequency Analysis between Study Periods

Period	All Implants	Brånemark Implants	Southern Implants
Surgery to 12 weeks*			
Mean change in ISQ	1.25 (± 2.81)	1.16 (± 2.89)	1.34 (± 2.82)
Mean change in RF (Hz)	76.10 (± 186)	84.40 (± 197)	68.21 (± 180)
12 to 64 weeks*			
Mean change in ISQ	3.20 (± 3.52)	2.56 (± 3.90)	3.88 (± 3.01)
Mean change in RF (Hz)	177.12 (± 204)	130 (± 225)	227 (± 172)

ISQ = implant stability quotient; RF = resonance frequency.
*No significant difference between systems.

48 ($\chi^2 = 4.67$, $df = 1$, $p = .03$). After loading with maxillary overdentures between 12 and 64 weeks, there were a further 4 failures (Brånemark implants, 1 failure in 1 patient; Southern implants, 3 failures in 2 patients). The total number of implant failures at 64 weeks was 15 (5 Brånemark implants and 10 Southern implants).

Specifically pertaining to marginal bone loss and to the implant stability tests of the loaded implants, the initial analysis of the data revealed no statistically significant differences in the outcome variables by implant system. For this reason, the two implant groups have been combined in the description of the results. Marginal bone loss from surgery to 12 weeks was 1.30 mm (± 0.44 mm), and bone loss from 12 to 64 weeks was 0.32 mm (± 0.48 mm). There were no significant differences by implant site (Figure 5). Implant stability measurements taken at surgery and at 12 and 64 weeks were in the range of 55 to 61 ISQ units and increased significantly over those time intervals ($p < .001$) (Table 4). There was no drop in RF values between surgery and 12 weeks. Mean changes in ISQ and RF values from surgery to 12 weeks are shown in Table 5. There was no significant difference between the two surgical procedures (OO vs ORS) in the initial implant stability readings at fixture placement. Slightly higher mean RF values were found after OO procedures, but this did not reach statistical significance. No significant association between the change in ISQ or RF value and Lekholm and Zarb classification[16] was found.

Cumulative survival rates and implant success rates using four-field tables are shown in Tables 6 and 7. Of 39 anterior implants placed in zone I, two failed before loading (cumulative survival rate, 94.9%); of the posterior implants, 9 of 78 placed in zone II failed before loading (cumulative survival rate, 88.5%). After loading with overdentures, three zone II implants failed and only one zone I implant failed.

TABLE 6 Life Table Analysis of Placed and Followed Implants, by Implant

Time Period	Total Implants	Failed	Deceased/ Dropout, Withdrawn	CSR (%)
Placement to loading (12 weeks)	117	11*	0	90.60
Loading to 1 year (12–64 weeks)	106	4†	3‡	84.61

CSR = cumulative success rate.
*Fifteen implant failures in 11 participants (2 participants had failures before and after loading; 13 participants with failures either before or after loading).
†Four implants put to sleep in three participants, but those participants also had failures.
‡Three implants dropped out in one deceased participant.

TABLE 7 Implant Success after 1 Year of Loading

	Total Implants ($n = 117$)	Brånemark Implants ($n = 60$)	Southern Implants ($n = 57$)
Success	95 (81%)	54 (90%)	41 (72%)
Survival	4 (3.5%)	1 (2%)	3 (5%)
Unaccounted for	3 (2.5%)	0	3 (5%)
Failure	15 (13%)	5 (8%)*	10 (18%)*

Adapted from Albrektsson, Zarb 1998.[48]
*No significant difference in failure rates ($\chi^2 = 2.22$, $df = 1$, $p = .14$).

DISCUSSION

To date, this study shows a 1-year cumulative survival rate of 84.61% when three narrow-diameter roughened-surface implants are placed into edentulous maxillas with a one-stage surgical procedure and a shortened healing period of 12 weeks. An ORS procedure was required when more advanced maxillary residual ridge resorption had occurred, and this procedure was associated with a lower probability of survival. This suggests that implant overdentures are more likely to be successful if the surgical option of an OO procedure is offered to the patient earlier, rather than waiting until considerable maxillary atrophy has occurred. This technique has been substantiated by animal research.[50] Our failures in the OO procedure were attributed to iatrogenic causes[51] when the implants were seen (at 12 weeks on panoramic radiographs) to have perforated the mesial sinus border. In the case of the ORS procedure, failures were attributed to partial fracture of the labial plate.[33] It has been suggested that sites with Lekholm and Zarb type 2 bone are not suitable for the OO procedure, and increased periimplant marginal bone loss is detected radiographically after 6 months of unloaded healing.[35] There is no strong evidence that variations in surgical technique during implant placement lead to superior success rates.[52] In this planned trial for these maxillary overdentures, as much careful attention as possible was given to the random allocation and concealment procedures of

the two implant systems[53,54] although we have clearly shown that this was not possible for the choice of surgical procedure. We feel confident in our estimate of the treatment effect for the three implants placed surgically in the edentulous maxillas.

Some authors urge caution with respect to either immediate loading in the edentulous maxilla or single-stage surgery.[5] Participants in our planned trial had their maxillary overdentures returned on the day of surgery, relined with a tissue conditioner. Thus there was an element of progressive (rather than immediate) loading.[55] The number of participants included in any study is directly related to the precision of the parameter being evaluated. Because of the difficulties of the precise nature of human research, we agreed with proposals that the inclusion of too many patients in a study with a new technique makes the trial more expensive and unethical if it is determined that it is an unnecessary intervention.[56] We acknowledge that our encouraging results at 64 weeks in this number of patients must be tempered by the need for prudent and detailed clinical and radiologic observation over a longer period. Although there are differences in the roughened-surface topography and diameter of the implant systems used, it was not our prime intention to compare the systems (and in any case, there was no statistically significant difference between the two systems' failure rates). Rather, we attempted to use the available support from two implant suppliers and from funding bodies as efficiently as possible to enable this study to be conducted and to maximize its statistical power.

We have presented RF values for one-stage maxillary implants after 12 weeks and 64 weeks supporting maxillary overdentures. These recordings are lower than the RF values of 7,053 $\pm$ 453 Hz for the anterior maxilla and 6,832 $\pm$ 551 Hz for the posterior maxilla previously reported by Sennerby and colleagues[57] for maxillary two-stage implants after 6 months of healing. They found values of 7,726 $\pm$ 527 Hz, 6,874 $\pm$ 497 Hz, and 6,528 $\pm$ 219 Hz, respectively, for bone of Lekholm and Zarb bone quality 2, 3, and 4, but those data also include mandibular implants. The maxillas in those cases may have been more severely resorbed. The RF values are also within the range of experiences with grafted maxillas on small numbers of patients (5,860 to 8,440 Hz).[58] Our ISQ results fall within the range of 57 to 82 ISQ units reported by others for partially edentulous jaws.[59] The implants in our study that failed had lower ISQ values (36 to 50). The marginal bone loss in our study can be contrasted with that of other studies in which there was also a significant difference between periimplant bone level after implant placement with osteotomes and at the end of the unloaded period.[33] In this study the authors reported that Lekholm and Zarb type 2 bone showed an average reduction of 1 mm compared to 0.4 mm in type 3 bone. These researchers concluded that the OO technique is not suitable for type 2 bone. The majority of the maxillary sites in our study were in type 3 or type 4 bone (anterior sites, 65%; posterior sites, 91%).

In a previous multicenter study on Brånemark implants supporting overdentures, 117 implants were placed in 30 edentulous maxillas.[29] The cumulative success rate (CSR) reported prior to loading on the 117 implants was 92.3% but dropped to 81.2% on 100 implants after 1 year of loading. After 5 years on 64 implants the CSR was 72.4%. In our study we placed 117 implants into 39 maxillas, with a CSR of 90.6% prior to loading, and followed 105 implants in 35 maxillas for 1 year of loading, with a higher CSR of 84.6%. Brånemark implant success rates for removable and fixed prostheses (calculated as a mean of maxilla and mandible) were 84% and 93%, respectively[7]; the failure rate was 13.3% for overdentures and 4.8% for fixed bridges.[60] It is relevant that current accepted surgical approaches to the maxilla for overdentures have varying CSRs of 94.2%[11] and 88.6%[9] and have failure rates of 15 to 43%.[61] It has been suggested that in the compromised maxilla, it may be better to place as many implants as possible (even if they are short) and use them to support a fixed prosthesis.[7] However, cost-benefit analysis does not favor the placement of more implants.[12] Although fixed maxillary prostheses are cited as being more likely to have a successful outcome, it is not clear whether the type of prosthesis or the type of alveolar ridge present at surgery has the greater influence on success.[7] It has been reported that a poor quality and/or quantity of alveolar bone accentuates the difference in success rates between removable and fixed implant prostheses. It has been recommended that anatomic conditions be identified[62] and presented whenever implant treatment results are published, both when standard protocols and when advanced techniques are used,[7] and we have followed this suggestion.

There is evidence that the outcome of implant treatment with Brånemark implants in the edentulous maxilla could be related to the preoperative shape and bone quality of the jaw.[63,64] Success rates at 5 years are thought to be better with greater quantities of denser bone at the time of surgery, as opposed to poorer jaw bone quality and small bone volume, with which greater implant failure is expected. Our findings clearly showed that the OO procedure was more likely to be used in minimally resorbed ridges (Lekholm and Zarb types A and B) whereas the ORS procedure was more often used for ridges with advanced resorption (Lekholm and Zarb types C and D). This is consistent with a proposed ''rule of thumb'' that most implants are successful in the maxilla when the bone is at least of Lekholm and Zarb B/C quantity and 2/3 quality.[7] Longitudinal research by the Toronto Implant Prosthodontic Unit[65] concluded that differences in jawbone quantity may have an even more profound influence on implant outcomes in the maxilla. The estimated risk of overall implant failure was two to three times greater with each increment on the Lekholm and Zarb quantity scale (from A to E), and the risk of implant failure increased 36 to 86% with each increment on the Lekholm and Zarb quality scale (from 1 to 4).

We therefore propose that delaying implant placement in the edentulous maxilla of patients with opposing mandibular two-implant overdentures warrants more costly and invasive surgical protocols. That will overcome the development of severe residual maxillary ridge resorption. Early intervention with fewer implants in a one-stage surgical protocol using an osteotome-only procedure would be less expensive or traumatic and would have acceptable success rates. Acknowledging a recent consensus in favor of mandibular implant overdentures but anticipating future directions,[66,67] we have presented the early results of an alternative conservative cost-effective surgical approach for planned maxillary overdentures.

CONCLUSION

Three narrow-diameter roughened-surface implants can be placed successfully in edentulous maxillas, using a one-stage procedure, and can be sufficiently osseointegrated after 12 weeks of healing to allow loading with overdentures for up to 1 year.

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